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Non-parametric Analysis of Efficiency Performance for Hospitals and Medical Centers in Vietnam

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Abstract

The purpose of this paper is to analyze the efficiency performance of the hospitals and medical centers in Vietnam by using a non-parametric approach, namely the data envelopment analysis (DEA) model. The data from the Economic Census for Enterprises by the General Statistics Office of Vietnam (GSO) consists of 44 observations, which include 17 hospitals and 27 medical centers in different provinces and cities in 2002. The results indicate that the average scale efficiency of the hospitals was 77.4 percent, while that of the medical centers was 58.7 percent. Further, hospitals were clearly more efficient than medical centers due to some possible factors. Locations in Hanoi and Ho Chi Minh city had no influence on either overall technical efficiency or scale efficiency. Despite differences in the results of testing the impact of net capital-labor ratio on efficiency for hospitals and medical centers, these organizations appear to operate in labor-intensive ways.

Key words: data envelopment analysis (DEA), hospital efficiency, Tobit regression, Vietnam

JEL Classification: C14, I19

1. Introduction

Thanks to the impressive social and economic achievements from the *Doi moi* (renovation) policies, which were initiated in 1986, the living standards of the Vietnamese people have been improved. Health-related indicators have been upgraded significantly. For instance, child mortality and under-five mortality rates decreased by 53.9% and 48.6%, respectively, during 1993–2004 (World Health Organization [WHO], 2006), and life expectancy at birth increased from 65.2 in 1995 to 70.4 in 2003 (Thanhnien Online, 2005). Among the various factors that contributed to improving the ranking of Vietnam in the Human Development Index (HDI) during the past decade, these achievements in the health sector were extremely important. To gain such substantial improvements, the development of the health care system, including hospitals and medical centers at different administrative levels, has been encouraged. In 2002, Vietnam had 17 central hospitals located in main cities or regional centers, and all 600 districts in the country had medical centers (Ministry of Health [MoH], 2003). There has been an increase over time in the percentage of the population able to access health services.

However, according to some reports, such as that of the WHO (2006), many problems remain in the operation of health care system. Human resources and quality of services are the most critical issues. Therefore, evaluation of operation efficiency for the hospitals and medical centers is still needed.

Various factors must be explored in analyzing operation performance of the hospitals and medical centers. These factors include financing, human resources, and ownership structure. In addition to these traditional indicators, analysis has focused on technical efficiency and scale efficiency in recent years. Among various methods, a non-parametric approach, commonly known as the data envelopment analysis (DEA) model, has been applied widely. To the best of our knowledge, there has been no such research for the hospitals and medical centers in Vietnam because almost all of the evaluation reports have been based on the traditional ways in which statistical reports are usually reviewed.

The objective of the paper is, therefore, to examine technical efficiency and scale efficiency of the hospitals and medical centers in Vietnam to determine whether their operations were efficient. The results are hoped to provide policy implications for policy makers and managers of hospitals and medical centers to improve efficiency performance. The paper is organized as follows. Section 2 makes an overview of the health care system in Vietnam with some information about its structure and human resources. A literature review efforts to measure efficiency of hospitals using the DEA model will be provided in Section 3. In Section 4, we will present methodology, data source and variables, and a model to evaluate the factors that could influence efficiency. The estimated results and analysis will be presented in Section 5. Section 6 provides some conclusions and indicates possibilities for further studies on the topic.

2. An Overview of the Health Care System in Vietnam

Over the past decade, the health care activities in Vietnam have been strongly promoted to meet increasing demand of the people. Therefore, the systematic development of hospitals and medical centers has also been encouraged. Recently, the health care system has come to be mixed between public and non-public health care providers. The public ones are still playing dominant roles, especially in prevention, research, and training. There are three levels of hospitals and medical centers: central level, provincial level, and district level. At the central level, the Ministry of Health (MoH) is responsible for management of the people's health care and protection. According to the *Vietnam Health Report 2002* by MoH, there were 17 central hospitals located in main cities or regional centers, such as Hanoi, Ho Chi Minh city (HCMC), and Hue city. Central hospitals are located at the highest technical level in terms of treatment and care; they have the responsibility to provide services that are not available at the provincial level (MoH, 2003). The provincial hospitals and medical centers are running under the direct management of the provincial health bureaus and its departments. These provincial organizations are equipped with qualified staff and appropriate equipment in order to support and provide technical guidance to district and commune health stations. All 600 districts in the country have health centers, and each health center had at least one general hospital with 50 to 100 beds. Table 1 provides information on the hospitals by administrative levels and specialities as of 1999.

Table 1: Number of Hospitals by Levels and Specialities, 1999

Types of hospitals & levels	***Facilities***		***Beds***		***Average size (facility/bed)***
	Quantity	***%***	***Quantity***	***%***	
Central	*17*	*2.1*	*8,530*	*8.3*	*502*
General	11	1.3	6,320	6.2	575
Specialized	6	0.8	2,210	2.1	368
Provincial	*196*	*24.8*	*51,694*	*50.6*	*264*
General	94	11.9	34,165	33.4	364
Specialized	59	7.5	13,348	13.1	226
Traditional medicine	43	5.4	4,181	4.1	97
District (all are general)	*519*	*65.7*	*37,411*	*36.6*	*72*
Hospitals of other sectors (all are general)	*58*	*7.3*	*4,550*	*4.5*	*78*
Total/Average	***790***	***100***	***102,185***	***100***	***129***

Source: MoH (2003)

In addition to the public hospitals and medical centers, the private health care scheme has also been expanding rapidly. All the private practitioners are monitored by the provincial Health Bureau. The number of private health stations has increased over time and is concentrated in cities and urban areas; 69.4% of private health facilities and 61.8% of private traditional medical practitioners were located in these areas in 1999 (MoH, 2003). The distributions of the hospitals and medical centers are biased, and this bias makes for difficulties in improving both the quality and quantity of provided health services. It can be seen from the data for Hanoi and HCMC against that for the two mountainous provinces in the north (Table 2).

Table 2: Biased Distribution of Private Health Facilities

Provinces/Cities	***Number of Private Health Facilities***	
	1998	***2001***
HCMC	7,105	8,917
Hanoi	3,751	4,594
Tuyen Quang	94	133
Lai Chau	54	66

Source: MoH (2003)

In terms of staff, the number has also increased swiftly over time. In the public health scheme, the number of staff increased from 212,103 people in 1986 to 230,548 people in 2000 (MoH, 2003). The quality of human resources improved greatly; qualified staff with Ph.D.s, Master's degrees, and professional qualifications increased the most. For example, the number of doctors with Ph.D. and Master's qualifications increased from 33,470 people in 1996 to 41,663 people in 2000. Vietnam has more doctors per 100,000 people than some other countries in the region, such as Malaysia, Thailand, and the Philippines.

There are, however, many issues that the health care system in Vietnam is facing. Although the private health care has grown swiftly recently, it is mainly active in outpatient care. Inpatient care, which is usually costly, is provided mainly by the public sector. According to WHO (2006), only 26% of private health facilities participate in primary health care activities. In addition, although the number of specialized hospitals and clinics has increased over time, they account for only 11.36% of health facilities and are therefore often overloaded. In general, the ratio of nurses to doctors is still very low. In a more broad view, Vietnam needs to deal with some current pressing and critical issues, including the quality of services, training programs for health staff, and a large disparity in access to health care facilities across regions and population groups.

3. Measuring Efficiency of Hospitals: Literature Review

Recently, the DEA approach has been used widely to evaluate the efficiency performance of hospitals. Using this approach to measure efficiency for the private hospitals in Australia, Webster *et al.* (1998) found that efficiency estimates for the sampled hospitals were not robust to changes of the sets of inputs-outputs. It was interesting to find that sometimes even small changes in input sets could produce very different results, specifically when outputs were disaggregated (Webster *et al.*, 1998). The overall conclusion of this study was that, although most hospitals were operating under decreasing returns to scale, technical efficiency appeared to be only marginally influenced by factors such as hospital type and scale.

Barbetta *et al.* (2001), by adopting an output-oriented DEA model, also estimated the technical efficiency of hospitals in Italy with the impact of ownership structure in the period 1995–1998. The efficiency scores showed that all types of hospitals in the sample—public and not-for-profit private ones—had a declining trend in technical efficiency during the period, particularly in 1998. An emerging finding of this study was that when considering discharged patients as output, public hospitals had more efficient performance on average, while their non-profit counterparts showed better performances when considering the length of stay as output.

Also using a DEA model, Castro (2004) analyzed the technical efficiency of 54 public hospitals in Chile. The estimated results showed that several hospitals were operating at a lower pure technical efficiency level and scale efficiency than the best-practice frontier, which was obtained based on relatively more efficient hospitals. The author showed that technical inefficiency ranged between 30.3 and 94.3 percent, implying that average hospitals consumed 30.3–94.3 percent more resources than needed to get the same levels of outputs (Castro, 2004).

In addition to being applied to an individual country, the DEA method has also been applied to compare the efficiency of the health schemes among countries. Tandon *et al.* (2000) estimated the efficiency of the health schemes in 191 countries in the world. After omitting and ignoring some uncontrollable exogenous factors, such as the AIDS epidemic, population density, and geographical location, the findings of the research indicated that the technical efficiency scores for these countries ranged from 8 to 91.4 percent. The authors, however, admitted that these scores merely reflected the possibility to improve the efficiency of these countries' health schemes in comparison with the most efficient country in the sample.

Steinmann *et al.* (2003) measured and compared the in(efficiency) of German and Swiss hospitals. Both models used—a standard DEA model and a restricted DEA model to reduce the impacts of reporting errors and get a more comparable frontier—showed that the technical efficiency gap between German and Swiss hospitals widened over time. According to the authors, this gap might reflect the fact that patients in Switzerland had a larger choice of hospital without being exposed to cost differences (Steinmann *et al.*, 2003), and that there were excessive inputs for a given output, i.e., low DEA efficiency, when inputs were valued by patients as quality indicators.

Hollingsworth (2003) summarized recent studies on the technical efficiency of hospitals around the world. The finding was that the average efficiency score in most studies was 0.834 for the US hospital system, which was predominantly characterized by privately provided health care insurance. At the same time, that of European countries (including the UK, Finland, Greece, Austria, Belgium, Norway, Spain, and France), in which health care was characterized by public provision, was about 0.892 (Hollingsworth, 2003). This finding meant that room remained to improve the efficiency in hospitals of the US and the sample European economies. The study also explained some possibilities that could bias these findings, such as methodological differences and heterogeneity of observations.

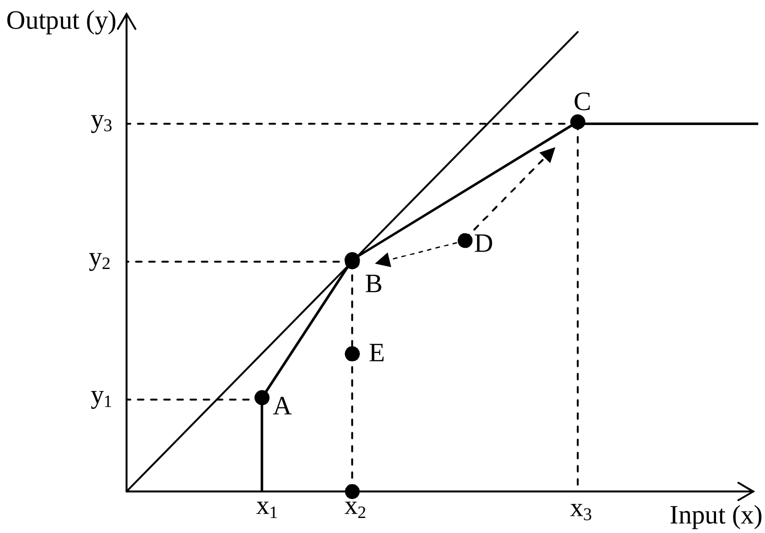
4. Methodology, Data, Variables, and Model Specifications

4.1. Methodology: Data Envelopment Analysis

As mentioned, the DEA approach has recently become the dominant approach to measure the performance of many economic sectors. One of the attractive characteristics of this approach is that it can deal easily with multiple outputs. In addition, DEA is a non-parametric approach, so it does not require any assumption about the functional form of the production or cost frontier. Therefore, DEA concentrates on taking into account and classifying variables that can be inputs or outputs of the production function.

Technical efficiency may be defined as the ability of a firm to produce as much output as possible, given a certain level of inputs and certain technology. Figure 1 illustrates this definition. In the figure, there are five points (A, B, C, D, E) associated with different levels of input and output. The line ABC describes the frontier for the production process. Observations A, B, and C are on the frontier, while observations D and E lie below the frontier. There exists a ray from the origin tangent to the frontier at point B. This ray represents the constant returns to scale of the technology represented by the data of those observations. In this example, observation B depicts relative technical efficiency, i.e., this firm is purely technically efficient and scale efficient due to its location on the frontier and the property of constant returns to scale.

Figure 1: Illustration of Technical Efficiency



Although a firm may be technically efficient in an overall sense, it is possible that it is experiencing inefficiency in scale. Observations A and C are purely technically efficient because they belong to the frontier, but they exhibit scale inefficiencies. Observation D is both scale and technically inefficient because it lies below the frontier. Theoretically, the same level of input could be used to achieve a higher level of output, which would allow the firm (at point D) to move forward to the frontier between points B and C. Observation E is purely technically inefficient because it lies below the frontier, but it is scale efficient because it produces at input level of x2—the scale-efficient level of input (or the same level of output as observation B).

In order to obtain separate estimates of technical efficiency and scale efficiency, we apply the input-oriented technical efficiency measurement to the data. This measurement must satisfy two different types of scale behavior: constant returns to scale (CRS) and variable returns to scale (VRS).

Let Y be an ($M \times N$) matrix of outputs of hospitals and medical centers in the sample, where the element y_{ij} represents the i^{th} output of the j^{th} hospital/medical center. Let X be a ($P \times N$) matrix of inputs, in which the element x_{kj} represents the k^{th} input of the j^{th} hospital/medical center and z an N-vector of weights to be defined. Elements of these vectors denote $z_1,\ldots, z_N$. The vector y_j ($M \times 1$) vector of outputs and x_j is the ($P \times 1$) vector of inputs of the j^{th} hospital/medical center.

The CRS input-oriented measurement of technical efficiency for the j^{th} hospital/medical center is calculated as the solution to the following mathematical programming problem.

$$\lambda_c^j = \min_{\lambda,z} \lambda, \tag{1}$$

subject to:

$$
\begin{cases}
y_{1i} \le y_{11}z_1 + y_{12}z_2 + \ldots + y_{1N}z_N \\
y_{2i} \le y_{21}z_1 + y_{22}z_2 + \ldots + y_{2N}z_N \\
\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
y_{Mi} \le y_{11}z_1 + y_{12}z_2 + \ldots + y_{MN}z_N \\
x_{11}z_1 + x_{12}z_2 + \ldots + x_{1N}z_N \le \lambda x_{1i} \\
x_{21}z_1 + x_{22}z_2 + \ldots + x_{2N}z_N \le \lambda x_{2i} \\
\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
x_{P1}z_1 + x_{P2}z_2 + \ldots + x_{PN}z_N \le \lambda x_{Pi} \\
z_j \ge 0 \text{ for all } j.
\end{cases}
$$

The scale value λ represents a proportional reduction in all inputs such that $0 \le \lambda \le 1$, and λ_c^j is the minimum value of λ, so that $\lambda_c^j x^j$ represents the vector of technically efficient inputs for the j^{th} hospital/medical center. Maximum technical efficiency is achieved when λ_c^j equals unity. In other words, if the DEA gives the outcome $\lambda_c^j = 1$, the hospital/medical center is operating at the best-practice and it is not able to improve its performance any further, given the existing set of observations. If $\lambda_c^j < 1$, we can conclude that the hospital/medical center is operating below the best-practice frontier.

The VRS technical efficiency for the j^{th} hospital/medical center is computed as:

$$\lambda_v^j = \min_{\lambda, z} \lambda, \tag{2}$$

subject to:

$$
\begin{cases}
y_{1i} \le y_{11}z_1 + y_{12}z_2 + \ldots\ldots + y_{1N}z_N \\
y_{2i} \le y_{21}z_1 + y_{22}z_2 + \ldots\ldots + y_{2N}z_N \\
\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
y_{Mi} \le y_{11}z_1 + y_{12}z_2 + \ldots\ldots + y_{MN}z_N \\
\\
x_{11}z_1 + x_{12}z_2 + \ldots\ldots + x_{1N}z_N \le \lambda x_{1i} \\
x_{21}z_1 + x_{22}z_2 + \ldots\ldots + x_{2N}z_N \le \lambda x_{2i} \\
\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
x_{P1}z_1 + x_{P2}z_2 + \ldots\ldots + x_{PN}z_N \le \lambda x_{Pi} \\
l_1 z_1 + l_2 z_2 + \ldots\ldots + l_N z_N = 1 \\
z \ge 0.
\end{cases}
$$

Given these two estimates of technical efficiency, the input-oriented scale efficiency measure for the j^{th} hospital/medical center is calculated as the ratio of CRS technical efficiency (or overall technical efficiency) to VRS technical efficiency (or pure technical efficiency). This means that:

$$S^j = \lambda_c^j / \lambda_v^j. \tag{3}$$

If the value of this ratio is equal to unity (i.e., $S^j = 1$), the hospital/medical center is scale-efficient, meaning that the hospital/medical center is operating at its optimum size, and hence that the productivity of inputs cannot be improved by increasing or decreasing the size of the hospital/medical center.

If the value of this ratio is less than unity (i.e., $S^j < 1$), the hospital/medical center is concluded to be not operating at its optimum size. In the first of two possible cases, (i), if $S^j<1$ and $\lambda_c^j = \lambda_n^j$, the scale inefficiency results from increasing returns to scale. In other words, increasing the size of the hospital/medical center helps to improve its productivity and thereby reduces unit costs. In the second possible case, (ii), if $S^j < 1$ and $\lambda_c^j < \lambda_n^j$, the scale inefficiency is due to decreasing returns to scale, indicating that the hospital/medical center can raise its productivity and lessen unit costs by choosing a smaller size.

Rearranging equation (3) we have the overall technical efficiency being the product of pure technical efficiency and scale efficiency:

$$\lambda_c^j = \lambda_v^j S^j . \tag{4}$$

Note that λ_v^j is also the pure technical efficiency, or the technical efficiency of the j^{th} hospital/medical center, less the inefficiencies due to scale.

Equation (4) shows two sources of technical inefficiency: scale inefficiency ($1–S^j$) and pure technical inefficiency ($1-\lambda_v^j$). In the absence of environmental differences (i.e., local government policies and other unspecified variables) and measurement errors of inputs and outputs, the pure technical inefficiency would reflect departures from the management of the best-practice hospital/medical center. Eliminating the latter source of inefficiency requires forming a benchmarking partnership with relevant best-practice hospitals/medical centers to identify and then emulate their management practices.

The output of DEA, therefore, includes measures of each hospital/medical center's overall technical efficiency, pure technical efficiency, scale efficiency, and the identification of its best-practice benchmark. The best-practice benchmark provides the potential benchmark partners associated with their respective contribution to the best-practice benchmark.

4.2. Data, Variables, and Factorial Effect Model

4.2.1. Data and Variables

The data used in this paper is firm-level data with 44 observations in 2002, which were selected from the Economic Census for Enterprises by the General Statistics Office of Vietnam (GSO) during 2000–2002. There were 17 hospitals and 27 medical centers in the sample for 2002. Census data for 2000 and 2001 was also available, but the numbers of observations for these two years were so small that they might make our estimates biased. Therefore, we chose only the observations of the year 2002 for this paper.

In our DEA model, we will use net revenue (r) as output and number of laborers (l) and net capital (kr) as inputs. Net revenue is calculated by subtracting from the total revenue all required payments, such as taxes and contributions. It is measured in millions of Vietnamese dong (VND). The number of laborers is calculated by the average number of laborers in the year, while net capital is calculated by subtracting depreciation from the total capital, and is measured in VND million.

Table 3 summarizes statistical information of all the mentioned variables. A wide gap can be seen between the observations in terms of all indicators. For example, the number of laborers varied between 5 and 410, and net revenue ranged from 10 to 61,397 million VND.

A detailed decomposition of the data for hospitals and medical centers in Table 1 also shows that hospitals in the sample were usually larger than medical centers in all indicators. For instance, the number of labors varied from 5 to 410, while that of medical centers ranged from 6 to 53, and net revenue of the studied hospitals was from 208 to 82,524 million VND, while that of medical centers was only from 10 to 9,623 million VND.

Table 3: Statistical Summary of Variables

	Obs.	*Mean*	*Std. Dev.*	*Min.*	*Max.*
All observations					
r	44	5,756.295	13,956.59	10	61,379
l	44	54.15909	85.49091	5	410
kr	44	8,881.477	18,474.58	13	105,902
Hospitals					
r	17	17,982.59	26,366.15	208	82,524
l	17	113.9412	120.6884	5	410
kr	17	22,189.5	30,564.53	13	105,902
Medical Centers					
r	27	1,628.259	2,357.635	10	9,623
l	27	23.33333	14.39885	6	53
kr	27	3,079.389	6,602.253	105.5	33,587

Source: Authors estimated from the dataset

By ownership, it is important to note that all observations were from the non-state sector. Out of 44 observations, the number of private, joint stock, joint venture, and foreign-invested hospitals and medical centers was 14 (or 31.8% of the total), 17 (38.6%), 8 (18.2%), and 5 (11.4%), respectively. Table 4 provides a statistical summary of all variables for these ownership types. Although the number of observations for each type of ownership was different, a large gap is obvious between the studied hospitals and medical centers in terms of all variables.

Table 4: Statistical Summary of Variables by Ownership

Ownership	*Obs.*	*Mean*	*Std. Dev.*	*Min.*	*Max.*
Private					
r	14	1,477.286	1,773.113	114	6,057
l	14	31.07143	28.16562	6	98
kr	14	2,348.357	4,016.502	13	14,681
Joint Stock					
r	17	8,798.824	18,778.13	0	61,379
l	17	73.23529	112.5914	5	410
kr	17	14,708.06	27,558.8	106	105,902
Joint Venture					
r	8	7,564.5	17,656.21	10	51,137
l	8	73.75	106.2245	18	335
kr	8	6,042.375	7,420.733	500	23,408
Foreign-invested					
r	5	4,499.8	3,972.054	0	9,623
l	5	22.6	10.57355	6	34
kr	5	11,906.4	12,692.91	256	33,587

Source: Authors estimated from the dataset

Many variables that could be used as inputs and outputs. Due to severe data limitations, however, we could only use these variables for our model.

4.2.2. Factorial Effect Model

By using the data and the data envelopment analysis program (DEAP) Version 2.1 (Coelli, 1996), we will estimate technical efficiency with constant returns to scale (or overall technical efficiency, *crste*), with variable returns to scale (or pure technical efficiency, *vrste*), and scale efficiency (*scale*). As previously mentioned, scale efficiency (*scale*) is the ratio between *crste* and *vrste*.

An important question is what factors appeared to be associated with technical efficiency of these hospitals and medical centers in the study year. Answering this question might help policy makers and managers of the sampled hospitals and medical centers to have alternative strategies to improve efficiency performance. In this paper, we will use the following model.

$$TE = \alpha_0 + \alpha_1 krl + \alpha_2 r + \alpha_3 r^2 + \alpha_4 loc + \varepsilon, \tag{5}$$

where *TE* is the efficiency score that will be estimated from the DEA approach; α_i (i = 1, 2, 3, 4) is the respective coefficient of the independent variables; *krl* is the net capital-labor ratio of each construction firm and is measured by the ratio between net capital *kr* and number of laborers *l*; *r* and r^2 are net revenue and squared net revenue, respectively, and they represent the firm size; *loc* is a dummy variable for locations in Hanoi and HCMC, with *loc* = 1 for firms located in Hanoi and HCMC and 0 otherwise; and ε is random error.

We can see that *krl* and *r* are crucial and determinant variables of technical efficiency of the hospitals and medical centers due to the following reasons. First, net capital-labor ratio (*krl*) represents technical intensification of the labor in these organizations, and it indirectly reflects that they are operating in labor-intensive or capital-intensive ways. Second, net revenue (*r*) shows their performance, particularly reinvestment in capital or human resources. Moreover, the estimated coefficients of *r* and r^2 might tell us whether there existed an efficient hospital or medical center with the smallest or largest size.

The dummy variable *loc* represents business location of firms in Hanoi, HCMC, and other provinces, and it indicates how the business environment influenced efficiency of the studied hospitals and medical centers. It is expected that the firms located in these two central cities have better efficiency performances than their counterparts in other parts of the country.

In this paper, we will use the factorial effect model for *crste* and *scale*. Since *TE* is upper-bounded by 1, we will use Tobit estimation for equation (5).

5. Empirical Results and Analysis

5.1. Estimated Efficiency Scores from DEA

Due to the different characteristics of hospitals and medical centers, we did not pool all the observations in the DEA model to estimate efficiency scores—we used different frontiers for hospitals and medical centers in order to compare among these studied observations. Table 5 indicates the estimates of efficiency scores for the full sample of 17 hospitals and 27 medical centers in 2002.

Table 5: Estimated Efficiency Scores for Individual Hospitals and Medical Centers

Hospital	crste	vrste	scale	rs
1	1.000	1.000	1.000	-
2	1.000	1.000	1.000	-
3	0.284	0.343	0.828	irs
4	0.631	0.657	0.961	irs
5	0.276	0.305	0.906	irs
6	0.312	0.324	0.961	irs
7	1.000	1.000	1.000	-
8	0.778	0.779	0.998	drs
9	0.474	0.478	0.991	drs
10	0.766	0.876	0.875	drs
11	0.769	0.770	0.998	drs
12	0.595	0.622	0.957	irs

Med.Center	crste	vrste	scale	rs
1	0.340	0.749	0.453	irs
2	0.240	0.750	0.320	irs
3	0.394	0.398	0.988	irs
4	0.365	0.534	0.684	irs
5	0.353	0.417	0.845	irs
6	0.831	1.000	0.831	irs
7	0.381	1.000	0.381	irs
8	0.605	0.630	0.962	irs
9	1.000	1.000	1.000	-
10	0.831	0.856	0.971	drs
11	0.131	0.600	0.218	irs
12	0.144	0.461	0.311	irs

13	0.881	0.882	0.999	irs
14	1.000	1.000	1.000	-
15	0.196	0.236	0.828	irs
16	1.000	1.000	1.000	-
17	0.147	0.321	0.457	irs
Mean	*0.474*	*0.613*	*0.774*	

13	0.278	0.445	0.624	irs
14	0.180	0.283	0.634	irs
15	0.454	0.569	0.797	irs
16	0.176	0.498	0.353	irs
17	0.177	0.749	0.237	irs
18	0.446	0.685	0.651	irs
19	0.554	0.624	0.888	irs
20	0.132	0.333	0.398	irs
21	0.223	0.311	0.716	irs
22	0.352	0.385	0.915	irs
23	0.004	0.128	0.033	irs
24	0.833	0.850	0.981	irs
25	0.866	0.896	0.967	irs
26	0.876	0.907	0.965	irs
27	0.373	0.470	0.792	irs
Mean	*0.337*	*0.574*	*0.587*	

Source: Authors' estimates

The average scale efficiencies of hospitals and medical centers were 0.774 (or 77.4%) and 0.587 (or 58.7%), respectively. This means that, on average, these hospitals and medical centers might respectively have needed only 77.4 and 58.7 percent of the current inputs (labor and net capital) to get the current outputs (net revenue) in 2002. In other words, their average operation inefficiency was respectively 22.6 percent and 41.3 percent in that year.

In addition, 8 out of 17 (or 47%) of the studied hospitals and 26 out of 27 (96.3%) of the studied medical centers showed that they were operating under increasing returns to scale (IRS), meaning that they could have improved their efficiency levels if they had increased inputs. Conversely, 4 out of 17 (23.5%) hospitals, and only 1 out of 27 (3.7%) medical centers were shown to be operating under decreasing returns to scale (DRS), meaning that these hospitals and medical centers should reduce inputs to achieve better efficiency. The remaining hospitals and medical centers were operating under constant returns to scale (CRS), so they did not need to change inputs because doing so would not yield any increase in efficiency scores.

Although the numbers of observations and operation characteristics of hospitals and medical centers were different, it is still interesting compare the estimated technical efficiency scores between them. In both cases where we allow CRS and VRS, the average score of the hospitals was absolutely greater than that of their counterparts. These obtained results support the assertion that, on average, hospitals usually have better conditions than do medical centers in terms of size, technology, and number of professional staff.

To see the differences of technical efficiency scores between hospitals and medical centers in the sample by ownership, Table 6 classifies the estimated results by ownership. It should be again acknowledged that the difference in the number of observations for each type of ownership makes comparing these estimates difficult.

The private hospitals and medical centers are shown to have had the highest scale efficiency in the year 2002 (at 79.4%). This was followed by those under joint venture with foreigners (at 65.2%) and the ones under joint stock (at 63.9%). The foreign-invested ones had the lowest scale efficiency (at 48.1%). This estimate is consistent with the information from the dataset that 13 out of 15 private hospitals and medical centers in the sample made a (net) profit in 2002, but only 1 out of 5 foreign-invested hospitals and medical centers could do so in that year (data are not shown in this paper). The number of (net) profit-making joint stock hospitals and medical centers was 11 out of 19, and that for joint ventures was 4 out of 9. Furthermore, out of 6 fully efficient hospitals and medical centers, 4 were private and 2 were joint venture.

Table 6: Efficiency Scores by Ownership

Private					*Joint Stock*				
Obs.	**crste**	**vrste**	**scale**	**rs**	**Obs.**	**crste**	**vrste**	**scale**	**rs**
1	1.000	1.000	1.000	-	1	1.000	1.000	1.000	-
2	1.000	1.000	1.000	-	2	0.778	0.779	0.998	drs
3	0.284	0.343	0.828	irs	3	0.474	0.478	0.991	drs
4	0.631	0.657	0.961	irs	4	0.766	0.876	0.875	drs
5	0.276	0.305	0.906	irs	5	0.769	0.770	0.998	drs
6	0.312	0.324	0.961	irs	6	0.595	0.622	0.957	irs
7	0.340	0.749	0.453	irs	7	0.881	0.882	0.999	irs
8	0.240	0.750	0.320	irs	8	1.000	1.000	1.000	-
9	0.394	0.398	0.988	irs	9	0.831	0.856	0.971	drs
10	0.365	0.534	0.684	irs	10	0.131	0.600	0.218	irs
11	0.353	0.417	0.845	irs	11	0.144	0.461	0.311	irs
12	0.831	1.000	0.831	irs	12	0.278	0.445	0.624	irs
13	0.381	1.000	0.381	irs	13	0.180	0.283	0.634	irs
14	0.605	0.630	0.962	irs	14	0.454	0.569	0.797	irs
mean	*0.477*	*0.601*	*0.794*		15	0.176	0.498	0.353	irs
					16	0.177	0.749	0.237	irs
					17	0.446	0.685	0.651	irs
					mean	*0.337*	*0.528*	*0.639*	

Joint Venture					*Foreign-Invested*				
Obs.	**crste**	**vrste**	**scale**	**rs**	**Obs.**	**crste**	**vrste**	**scale**	**rs**
1	1.000	1.000	1.000	-	1	1.000	1.000	1.000	-
2	0.196	0.236	0.828	irs	2	0.147	0.321	0.457	irs
3	0.554	0.624	0.888	irs	3	0.866	0.896	0.967	irs
4	0.132	0.333	0.398	irs	4	0.876	0.907	0.965	irs
5	0.223	0.311	0.716	irs	5	0.373	0.470	0.792	irs
6	0.352	0.385	0.915	irs	*mean*	*0.245*	*0.510*	*0.481*	
7	0.004	0.128	0.033	irs					
8	0.833	0.850	0.981	irs					
mean	*0.437*	*0.671*	*0.652*						

Note: crste: overall technical efficiency; vrste: pure technical efficiency; scale: scale efficiency = crste/vrste; rs: scale type; irs: increasing returns to scale; drs: decreasing returns to scale; -: constant returns to scale

Source: Authors' estimates

In addition, the information from Table 6 provides suggestions for these studied hospitals and medical centers. It is shown that 12 out of 14 (or 85.7%) private, 7 out of 8 (87.5%) joint-venture, 4 out of 5 (or 80%) foreign-invested, and 10 out of 17 (or 58.8%) joint stock hospitals and medical centers were operating under IRS technology. This means that if they had been able to increase inputs, they would also have been able to increase output. Only some joint-stock hospitals and medical centers were operating under DRS technology, meaning that they should reduce inputs to achieve better efficiency.

5.2. Factorial Effects Model

In order to see which factors could be determinants of the efficiency performances of the studied hospitals and medical centers, we use the model indicated in equation (5) with Tobit regression. In this section, we will test the factors that might influence overall technical efficiency (*crste*) and scale efficiency (*scale*).

Table 7 shows the estimated results from the factorial effect model for *crste* and *scale*, in which we use pooled data of all 44 observations.

Table 7: Factors that Influenced Overall and Scale Efficiency: Pooled Data

Log likelihood = -3.3826697			Number of Obs. = 44		
			LR chi2(5) = 17.85		
crste	Coef.	Std. Err.	P>t	[90% Conf. Interval]	
krl	.0000691	.0000366	0.066	7.45e-06	.0001308
r	.0000245	8.76e-06	0.008	9.78e-06	.0000393
r2	-2.41e-10	1.23e-10	0.056	-4.47e-10	-3.44e-11
loc	-.008419	.0844717	0.921	-.1506568	.1338187
_cons	.3937821	.0585587	0.000	.2951779	.4923862
Log likelihood = -1.0950579			Number of Obs. = 44		
			LR chi2(5) = 12.52		
scale	Coef.	Std. Err.	P>t	[90% Conf. Interval]	
krl	.0000467	.0000344	0.182	-.0000112	.0001046
r	.0000259	8.23e-06	0.003	.000012	.0000398
r2	-2.96e-10	1.15e-10	0.014	-4.90e-10	-1.02e-10
loc	-.1019055	.0793334	0.206	-.235491	.0316801
_cons	.7130968	.0549285	0.000	.6206053	.8055883

Source: Authors' estimates

At the significance level of 10 percent, Table 7 indicates that the coefficient of the variable *krl* is statistically significant and different from 0 for *crste*, while it is not statistically significant for *scale*. This means that the net capital-labor ratio had an impact on the overall technical efficiency and did not have any influence on the scale efficiency of the studied hospitals and medical centers. In other words, these hospitals and medical centers might be operating in heavily labor-intensive ways, and thus investments in human capital would be better than physical expansion for improving their efficiency performance.

Moreover, in both estimates, the coefficients of r and r^2 are also statistically significant, and the coefficient of r is positive, while that of r^2 is negative. This means that there existed an efficient hospital or medical center that had the largest size. Similarly, the coefficient of *loc* is not statistically significant in either estimate, so locations of the hospitals and medical centers in Hanoi or HCMC did not have impacts on either technical efficiency or scale efficiency. This result might not be surprising because more than 70 percent of the hospitals and medical centers in the sample were located in these central cities.

To make a comparison between hospitals and medical centers in terms of factorial effects, we used Tobit regression for separate samples of hospitals and medical centers. The estimated results for *crste* and *scale* of these studied organizations are presented in Tables 8 and 9.

Table 8: Factors that Influenced Overall Technical Efficiency (crste): Separate Data

HOSPITALS					
Log likelihood = -1.6081492			Number of Obs. = 17		
			LR chi2(5) = 8.49		
crste	Coef.	Std. Err.	P>t	[90% Conf. Interval]	
krl	.000085	.0000423	0.066	9.99e-06	.0001599
r	.0000211	.0000117	0.094	4.00e-07	.0000417
r2	-1.71e-10	1.46e-10	0.262	-4.29e-10	8.72e-11
loc	-.2122942	.181564	0.263	-.5338319	.1092436
_cons	.4962352	.0939641	0.000	.3298312	.6626393

MEDICAL CENTERS					
Log likelihood = 6.4724453			Number of Obs. = 27		
			LR chi2(5) = 23.34		
crste	Coef.	Std. Err.	P>t	[90% Conf. Interval]	
krl	-.0005712	.000195	0.008	-.0009054	-.000237
r	.0002204	.0000496	0.000	.0001355	.0003054
r2	-1.49e-08	5.54e-09	0.013	-2.44e-08	-5.42e-09
loc	.0285721	.0739518	0.703	-.0981719	.155316
_cons	.2334635	.0599884	0.001	.1306511	.3362758

Source: Authors' estimates

Table 9:Factors that Influenced Scale Efficiency (scale): Separate Data

HOSPITALS					
Log likelihood = 9.8403507			Number of Obs. = 17		
			LR chi2(5) = 5.52		
scale	Coef.	Std. Err.	P>t	[90% Conf. Interval]	
krl	.000029	.0000198	0.168	-6.17e-06	.0000641
r	.0000113	5.43e-06	0.058	1.68e-06	.0000209
r2	-1.13e-10	6.82e-11	0.121	-2.34e-10	7.62e-12
loc	-.1676024	.0837328	0.067	-.3158876	-.0193172
_cons	.9041137	.044255	0.000	.8257409	.9824864
MEDICAL CENTERS					
Log likelihood = 5.8321939			Number of Obs. = 27		
			LR chi2(5) = 25.05		
scale	Coef.	Std. Err.	P>t	[90% Conf. Interval]	
krl	-.0004007	.0001971	0.054	-.0007385	-.000063
r	.0002791	.00005	0.000	.0001934	.0003649
r2	-2.30e-08	5.59e-09	0.000	-3.26e-08	-1.34e-08
loc	-.0605643	.0746338	0.425	-.188477	.0673485
_cons	.4698444	.0603439	0.000	.3664227	.5732661

Source: Authors' estimates

At the significance level of 10 percent, Table 8 shows that the coefficient of *krl* is statistically significant. The positive coefficient of *krl* for hospitals indicates that investments in more advanced technology would help them to improve technical efficiency, while the negative coefficient of *krl* for medical centers implies that they should invest in more human capital. In both estimates, *r* had a positive influence on technical efficiency. In addition, the coefficient of r^2 for the medical centers means that there existed an efficient medical center that had the largest size. Similarly, the variable *loc* did not have any impact on technical efficiency, and this result could be elucidated with the reason mentioned in the pooled estimates.

Table 9 shows that the coefficient of *krl* for the hospitals is positive and statistically insignificant at the significance level of 10 percent. This implies that physical expansion of these hospitals, particularly in the size of staff, would not enhance their efficiency performance. Similarly, the negative and statistically significant coefficient of *krl* for the medical centers indicates that these centers were over-employing staff for their operations. It is also shown that *r* had a positive impact on the scale efficiency of hospitals and medical centers, so diversification of revenue sources would be an optional way for efficiency improvement. The estimated result in Table 9 for r^2 in medical centers shows that there existed an efficient center that had the largest size. Table 9 shows a different implication of location: locations in Hanoi or HCMC seem not to have had any impact on scale efficiency of medical centers, while such locations had a negative impact on the scale efficiency of hospitals.

6. Concluding Remarks and Recommendations

This paper made use of a data envelopment analysis (DEA) approach to measure the technical efficiency of the hospitals and medical centers in Vietnam in 2002. The estimated results in the paper could be summarized as follows.

First, the average scale efficiency score for the hospitals and medical centers was 77.4 percent and 58.7 percent, respectively. This indicated excessive use of inputs to obtain the same level of output in 2002. These hospitals and medical centers could have achieved the same output in 2002 with respectively 22.6 percent and 41.3 percent less input. Due to different numbers of observations in terms of business (hospital or medical center) and ownership structure (private, joint-venture, joint-stock, or foreign-invested), we could not produce strong implications from the different efficiency estimates. However, in general, hospitals were absolutely more efficient than medical centers. This might be explained by the fact that hospitals usually have more technological and professional inputs than their counterparts.

Second, although the estimated results from pooled data and separate data provided different roles of net capital-labor ratio (*krl*), it was mainly shown that these studied hospitals and medical centers were operating in heavily labor-intensive ways. Thus, improving human resources would help them to upgrade their efficiency performances.

Third, geographical locations in Hanoi and HCMC generally had no influence on the technical and scale efficiency of these organizations in the year 2002. This result could be explained by the fact from the data sample that more than 70 percent of them were located in these central cities.

Although the results could provide some implications for the sector, this study could not avoid some limitations. Because all the observations in the sample were from the non-public sector, we could not make any comparative study with the hospitals or medical centers in the public sector. Further studies should address this limitation. Moreover, the lack of time-series data also made for uncertainties in analysis of operations. Some other limitations of this paper derive from the approach itself. First, DEA does not take into account statistical errors, so errors in measuring efficiency scores are possible sources of biased indications. Second, the estimated results from DEA are highly sensitive to the sample size, in which it is easy to make conclusion that some observations are fully efficient when the sample size is small. Thus, the estimated results and analysis in this paper need to be considered thoroughly using more appropriate and comprehensive approaches.

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